Aerosol Effects on Cold Season Orographic Precipitation and Water Resources in the Western U.S.

A proposal by
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ABSTRACT

Over 80% of the water supply in the western U.S. is provided by snowpack runoff. Long term changes in temperature and precipitation can have significant impacts on snowpack in the mountains. Besides the emission of greenhouse gases, human activities have also caused large scale changes in the chemical composition of the atmosphere. How aerosols affect the hydrological cycle may have serious global and regional consequences. By analyzing long term precipitation data, Givati and Rosenfeld (2004) showed significant loss of precipitation over topographical barriers downwind of major coastal urban areas in California. *We hypothesize that aerosols can reduce the orographic enhancement of precipitation in mountains downwind of urban areas and result in redistribution from the snowpacks on the ridges to the semi-desert lowlands, and a net loss of precipitation in the mountains.* On top of greenhouse warming that depletes snowpack, a potential net loss of precipitation due to anthropogenic aerosols can have serious consequences on water resources of the western U.S. This project aims to combine data analysis and modeling to investigate this hypothesis and address the following questions:

- What aerosol effects on the regional water cycle can be inferred from historical data and remote sensing data? How well can these effects be detected from observational data?
- What cloud-aerosol interaction and microphysical processes are important in determining the effects of aerosols on cold season orographic precipitation? How sensitive are the aerosol effects to synoptic conditions and orographic features?
- What are the potential impacts of greenhouse warming and air pollution on water resources in the western U.S.?

Data analysis will focus on determining the decreasing trends in orographic enhancement of precipitation based on historical climate records, and connecting the reduced orographic precipitation with changes in cloud properties to elucidate the processes that likely caused the trends. Analysis will be performed using satellite retrievals of cloud droplet radius, in conjunction with simultaneous precipitation structures as obtained from spaceborne (TRMM and AVHRR) and ground based radars.

A regional climate model will be applied at 10-20 km resolution to represent the influence of the complex terrain on precipitation. The model will include a bulk cloud microphysics parameterization with a prognostic equation of cloud droplet number that relates aerosols to cloud microphysical processes. Effects of uncertainty associated with model representations of aerosol-cloud interactions and microphysical processes will be investigated using sensitivity experiments. Long term simulations will be performed for relatively pristine and polluted environments. Differences in the orographic enhancement factors between the two simulations will be compared to the observed trends. Lastly, two 20-years simulations will be performed with the regional climate model driven by global climate simulations for 1975-1995 and 2040-2060 to examine the combined impacts of greenhouse warming and aerosols on water resources in the West.